The Canadian Air Quality Health Index

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Abstract

Air pollution can cause both short and long term impacts on human health. A new tool, the Air Quality Health Index, has been developed in Canada to provide the public with a real time indication of short term health risks associated with air pollution concentrations. The Air Quality Health Index (AQHI) builds upon existing indices of air pollution but differs by being based on a rigorous statistical link between mortality and air quality. The development of the AQHI in Canada was aided by recent advancements in health effects research, pollutant monitoring and reporting, weather and air quality prediction systems, efficient dissemination processes and political support. More heavily urbanized areas generally experience higher AQHI values than smaller communities.

The AQHI is a function of three common air pollutants: ozone, nitrogen dioxide and $PM_{2.5}$ (Particulate matter of maximum diameters 10 and 2.5 microns (millionths of a metre) respectively). It normally varies from 1 to 10, though it can occasionally rise above 10 during severe pollution episodes, such as thick wildfire smoke. The AQHI and its predicted maximum values for the next 24–36 h are provided to the public through various websites, with specific health advice provided for each of four AQHI health risk categories. The vulnerable population receives more cautious health advice than the general public. Promotion campaigns are used to explain the AQHI and encourage its use.

Keywords

Air quality health index · Health risk of air pollution · Health effects · Health risk · Health communication · AQHI · Cote air santé · Québec

18.1 Introduction

It has been estimated that approximately 5900 premature deaths result from short- and long-term exposure to air pollution in Canadian cities annually (Judek et al. 2004). This has been compounded by a continuing demographic shift toward urban living, where high pollution concentrations are often more prevalent, thereby increasing exposure of the overall population. In addition, over three million Canadians have serious respiratory diseases, making them more vulnerable to air pollution events. The elderly are also at increased health risk (Pope et al. 1995), and since the fraction of the Canadian population 65 and older continues to climb—from 8% in 1971 to 15% today—more widespread adverse effects are expected in this vulnerable population.

Chapter 7 in this book provides ample evidence of the impacts of degraded air quality on human health. The significance of these impacts has been compounded by the political demand to reduce health-related air pollution costs. For example, air pollution impacts in Ontario have been estimated at one billion dollars annually by the Ontario Medical Association. For these reasons, Canada has developed the Air Quality Health Index (AQHI) to help the public reduce the short term health risk associated with air pollution. This

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chapter provides a description of the AQHI, including its development and how it is communicated to the public.

18.2 Background of Air Pollutant Indices

Indices of air pollution are among the longest running and most successful of public environmental risk communications (Goldberg 2002; Johnson 2003). They serve to simplify the interpretation of air pollution by transforming measured concentrations of pollutants into a single number and/or categorical description. These indices are usually accompanied by a clear descriptive term (e.g. *poor* air quality) along with understandable health advice and/or prescriptive messages that provide more information on the pollutants.

In 2001, the only daily health advice available to address air pollutant concerns in Canada was the Air Quality Index (AQI). This index had been developed in the 1970s to report the amount of air pollution relative to national and provincial air quality objectives. It focused only on the most predominant pollutant of several that are known to impact heath. It was also based on the assumption that health impacts to humans do not occur below a given threshold of pollutant concentration, an assumption that is now not generally shared among air quality health professionals. Below this pollutant threshold, concentrations generally equated with "good" or "very good" air quality, depending upon the jurisdiction. Above this threshold, the AQI was used to communicate pollutant concentrations that reflected arbitrary government air pollutant objectives or standards at different tiers of air pollutant concentrations (i.e., desirable, acceptable and tolerable) using a mixture of health and non-health endpoints incorporated into the objectives (e.g. damage to vegetation).

The algorithm used to calculate the AQI is not the same across all jurisdictions since each has different air quality objectives. They are therefore not directly comparable. They also can have different numbers of, and labels for, air quality descriptors. For example, the United States' version of the AQI currently uses six categories that imply different levels of health impacts of air quality:

1. Good
2. Moderate
3. Unhealthy for Sensitive Groups
4. Unhealthy
5. Very Unhealthy
6. Hazardous.

In contrast, the province of Ontario, Canada, defines only five categories of the AQI, with quite different labels:

1. very good
2. good
3. moderate
4. poor
5. very poor.

In the US, the UK and in some provinces of Canada, air quality alerts are issued when the AQI exceeds certain thresholds and enters the "poor" or "unhealthy" category, though the criteria for issuing these alerts varies with jurisdiction. These thresholds also use a number of different averaging periods ranging from 1 to 24 h, depending on the pollutant. Some Canadian provinces, including British Columbia, do not report the AQI explicitly but retain it as a basis for issuing air quality advisories or alerts.

While health impacts were likely the major consideration in developing the AQI, Canadian users such as health care organizations began to question the value of the AQI in the late 1990s since it had not incorporated evolving evidence of air pollutant impacts on health. The AQI also had not had the benefit of recent epidemiological evidence that showed airborne pollutants had cumulative health effects. It also suggested that there were concentrations where no health risk existed, while we now know that there are no such pollutant thresholds. Since the AQI was also being implemented independently and differently in each Canadian province, users felt that the AQI "system is not a very good indicator for the health impact of air quality." (Pengelly et al. 2001). At the same time, public opinion research indicated a strong demand to reduce the risk from air pollution.

18.3 The Origin of the Air Quality Health Index

In 2001, Dr. Sheela Basrur, the Toronto Medical Officer of Health recommended improving the Air Quality Index (AQI) and the smog warning system in the province of Ontario. She also recommended that the revised system be applicable to other jurisdictions in Canada. Her recommendations included continuous monitoring of PM_{10} and $PM_{2.5}$ in Toronto, using the latest health research to improve the descriptions of air quality in each index category and incorporating the cumulative health impacts of multiple pollutants.

These recommendations led to Environment Canada (EC) initiating the development of a daily prediction of short-term human health risks associated with poor air quality across Canada. It was assumed at the time that such a prediction could be used as a communication tool to express the cumulative risks to humans of atmospheric pollutants in order that those susceptible to poor air quality would make more informed choices to protect themselves and those in their care from short term health impacts.

The timing of EC's decision to proceed with tool development was as a result of a confluence of political, environmental, social, economic, and legal factors that had evolved during the previous decade. For example, various air quality stakeholders had expressed concern over the cumulative impacts of air pollution on Canadians and a variety

of government agencies were working on various domestic and international fronts to improve air quality management regimes. Meanwhile, scientific and technical advances were being made in the form of increased meteorological data availability and computational processing speeds as well as advances in epidemiological methodologies that more accurately correlated human health impacts to air quality. These factors culminated politically in 2001 in a speech made at the 2001 Smog Summit in Toronto by the Minister for Environment Canada:

> We need an up-to-date national air quality index that…tells people how bad air pollution is in their community and that is supported by health and action messages. I am challenging scientists, health experts and communications specialists both inside and outside government to give us this tool within a year.

This challenge provided EC with the political capital needed to mobilize resources and marked its formal engagement in a process to innovate a new health communications tool that would later be called the Air Quality Health Index. Canada's Departments of Health and Environment, in collaboration with the provinces, territories, universities and other stakeholders, then began the development of the Index. It needed to be based on solid health science, take into account the multiple-pollutant impact on health and provide individuals with clear health advice that could help them reduce the health risk caused by degraded air quality. This advice would include guidance on changing behavior that could reduce exposure to pollutants. It would also increase awareness and response to early symptoms of disease that may be caused in part by air pollutants. It could also identify contributing risks such as excessive heat or strenuous exercise that should be avoided. Individuals, particularly the elderly, the very young and others at risk, were to use the Air Quality Health Index to help protect themselves from the negative effects of degraded air quality. This type of advice required convincing and informative communication tools that were able to update the public about air pollution in near real-time so that they can take actions to appropriately protect their health (Cantwell, personal communication 2012).

The stakeholder community was involved extensively in the development and implementation of the AQHI (Henderson et al. 2004). They provided advice on defining the index, identifying the audiences, and on testing the AQHI communication materials and processes. A testament to the success of this process was the declaration by the Auditor General of Canada that its development was a model of stakeholder engagement (Office of the Auditor General of Canada 2009).

18.4 The Development of the Air Quality Health Index

18.4.1 Foundation of the AQHI

Developers of the new Air Quality Health Index were able to build on several new scientific, engineering and political advances (Cantwell, M. Personal communication):

- **Health Effects Research**: As noted above, there had been significant advances in air health effects research since the old, single-pollutant AQI was introduced in the 1970s. The most significant finding is the linkages between adverse health effects and $PM_{2.5}$ (Pope et al. 1995). In addition, research has shown that adverse health effects have been found to occur at even low levels of air pollution, which were previously regarded as safe (WHO 2000), suggesting that all levels of air pollution are associated with at least some hazard. Also, since health is impacted by cumulative effects of all pollutants that are present in the air (WHO 2000), multiple pollutants were incorporated into the new Air Quality Health Index.
- **Monitoring and reporting**: Weather and air pollutant monitoring technology has improved significantly since the 1970s. This has resulted in more accurate measurement of pollutant concentrations, measurement of more types of pollutants and faster and more reliable transfer of air pollutant data from the monitoring equipment to data management centres. Also, the systems that organize, quality control and disseminate this air quality information to the public in real time have become more efficient and effective.
- **Prediction of air quality changes:** Variable weather conditions are an important predictor of hourly and daily changes to air quality and the AQHI in a community. Stagnant atmospheric conditions coupled with pollutant emissions are often a precursor to degraded air quality while increasing winds and atmospheric turbulence can dilute pollutants and quickly improve air quality. Prediction of air quality is generally aided by the use of both weather and air quality forecast models, which have advanced significantly since the 1970s. In addition, these models have benefitted from improved pollutant emissions inventories and data assimilation techniques as described in the chapters in this book on air quality modelling and forecasting.
- **Political commitment:** The national political environment played a significant role in the impetus to develop a new Air Quality Health Index. The most significant event was a commitment made in the spring of 2001 by the Canadian Minister of the Environment, the Honourable David Anderson, to pursue implementation of an improved "tool" for communicating air quality information to Canadians. In addition, bi-lateral advisory bodies like the International Joint Commission identified the availability of new air

quality information tools such as air quality indices and health based advisories as one of the six critical issues for Canada and the United States to address.

18.4.2 The Design of the Three-pollutant AQHI Formula

As evidenced by the series of deadly air pollution events in Europe and the US referred to in Dave Stieb's chapter in this book, increased air pollutant concentrations appear to coincide with increased mortality rates. However, even at lower concentrations experienced in Canada, air pollution is still associated with increased mortality (Stieb et al. 2008). The formulation of the new Air Quality Health Index was therefore based on a model linking daily deaths with daily concentrations of individual air pollutants. The modeling approach assumed a linear relationship between air pollution and mortality, consistent with the large body of evidence indicating that health effects are observed even at low levels of exposure.

The air pollutant and mortality associations were based on statistical links between daily 3-hour maximum concentrations of air pollution measurements and daily mortality rates in twelve Canadian cities over ten years. The AQHI was then adjusted to a 1–10 scale, and calculated hourly on the basis of trailing 3-hr average pollutant concentrations (Stieb et al. 2008). Though the AQHI was based on data that gave it a range of 1–10, in practice values well above 10 have subsequently been observed in extremely polluted air in Canada, mostly in smoke from severe wildfires.

Several different combinations of pollutants were considered for the AQHI in order to best reflect the mix of pollutants. The final formulation was based on mortality associations with only three pollutants: nitrogen dioxide, ozone, and $PM_{2.5}$. This combination of pollutants exhibited the strongest associations with mortality in large cities, and the addition of other pollutants did not add significantly to the overall health risk (Stieb et al. 2008). Because the AQHI was based on data from large cities, it should be noted that it may not be as applicable to small communities or rural settings that have a completely different pollutant mix than that used in the development of the index. This will be discussed in more detail later.

The current AQHI formula is:

$$\text{AQHI} = 10/10.4 * \left(100 * \left(e^{(0.000871 * \text{NO}_2)} - 1 + e^{(0.000537 * \text{O}_3)} - 1 + e^{(0.000487 * \text{PM}_{2.5})} - 1\right)\right)$$

In this equation, NO_2, O_3 and $PM_{2.5}$ (nitrogen dioxide, ozone and fine particulate matter less than 2.5 microns in diameter, respectively) refer to concentrations averaged over three consecutive hours. Units are parts per billion for the gases and micrograms per cubic metre for $PM_{2.5}$.

18.4.3 Accounting for Other Pollutants

Though the three pollutants in the AQHI have direct health impacts, some, particularly nitrogen dioxide, are more likely surrogates for other pollutants originating from the same sources such as ultrafine particles, VOCs or other substances that impact health but that are not included in the AQHI formula (Hidy and Pennel 2010). These other pollutants may mimic the variations in concentrations of the three AQHI component pollutants, particularly when they are produced by the same processes.

For example, in large cities, vehicle exhaust is a prime source of NO_2. But in addition to NO_2, fuel combustion in vehicles produces emissions of hundreds of other products that may be included in the measured direct health effects of NO_2, even though only NO_2 is routinely monitored. It is unknown how much of the health impact assigned to NO_2 in the AQHI is caused by the other pollutants contained in vehicle exhaust. Future improvements in the AQHI formulation may be needed to improve its correlation with health impacts in those locations where vehicle exhaust is not the primary source of NO_2, such as in smaller communities in rural, forested or agricultural areas.

18.4.4 Mortality vs Health and the AQHI

Though the AQHI is intended to provide an estimate of *health* risk, its formula is based on the statistical relation between *mortality* and air pollution. However, the contention of health scientists is that there is coherence between mortality and health. That is, the association between air pollution and a severe outcome like mortality broadly reflects impacts on a variety of health outcomes (Bates et al. 2003). In addition, in the process of developing the AQHI, numerous sensitivity analyses were conducted, including substitution in the AQHI formula of risk estimates based on hospital admissions rather than mortality. It was found that the AQHI performed similarly—i.e. the distribution of AQHI values was similar and values based on the mortality and hospital admissions-based formulas were highly correlated. More recently, analyses have also found associations between the AQHI and other health outcomes including asthma hospital admissions in Ontario, cardiac and respiratory hospital admissions in 24 Canadian cities, stroke emergency visits in Edmonton and asthma symptoms in Windsor.

18.5 AQHI Values in Canadian Cities

The majority of hourly values of the AQHI across Canada fall within the Low Health Risk category (AQHI less than 3.5). Figure 18.1 shows distributions of the relative frequen-

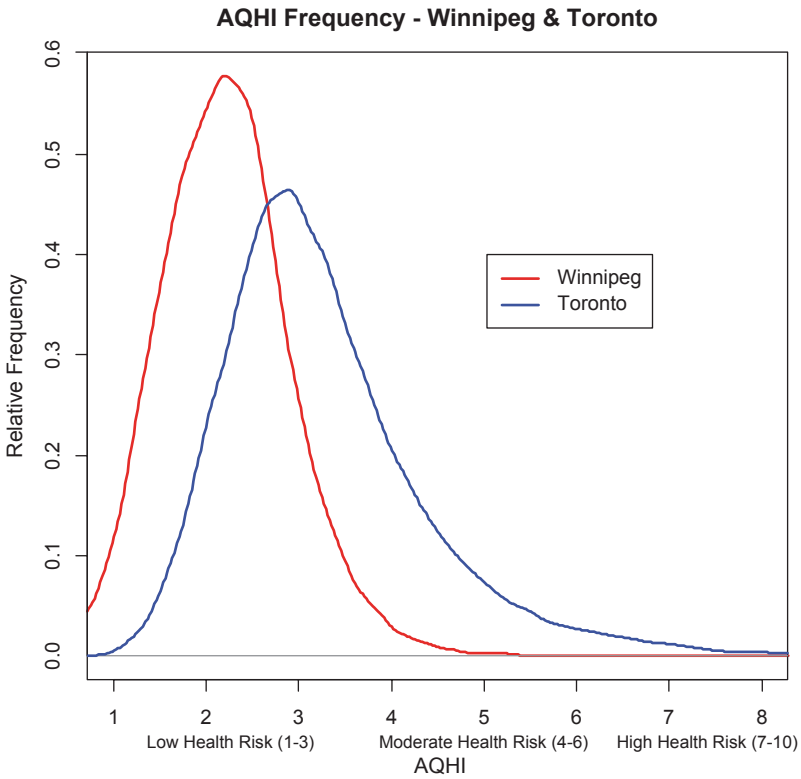


Fig. 18.1 A graph comparing the relative frequency of the AQHI at Winnipeg and Toronto. Toronto has the higher short-term health risk since the most frequent value of the AQHI is higher in that city, and the AQHI is also in the Moderate (3.5–6.5) and High (6.5–10.5) Health Risk categories more frequently. Areas under each curve are equal. Based on data from 2001–2009. (Data courtesy of Environment Canada)

cy of occurrence of the AQHI at two typical Canadian cities, Winnipeg (pop. 640,000) and Toronto (pop. 4,800,000). The shapes of the distributions are quite different, with the most frequent AQHI values for Winnipeg being 2.2, while Toronto is higher at 3.0. Figure 18.1 also shows that Toronto is in the Moderate Health Risk (AQHI between 3.5 and 6.5) and High Health Risk (6.5 to10.5) categories much more frequently than the less urbanized city of Winnipeg. This suggests that the short term health risk from air pollution is higher in Toronto than Winnipeg. Very high health risk (above 10.5) is rare in all locations in Canada, occurring much less than 0.1 % of the time (Hasselback and Taylor 2009), and usually being associated with infrequent events like wildfire smoke.

The AQHI at six Canadian cities is compared in Fig. 18.2, These figures suggest that Calgary, Montreal and Toronto experience a higher incidence of short term health risk due to degraded air quality than Winnipeg, Vancouver or Saint John.

The three constituent pollutants of the AQHI do not contribute equally to the AQHI. For example, in Kelowna, British Columbia, Fig. 18.3 shows that ozone and nitrogen dioxide account for the bulk of AQHI value, while $PM_{2.5}$ contributes only about 10 %. However, the relative contribution of $PM_{2.5}$ begins to climb as the AQHI exceeds 4, and it becomes the dominant pollutant at higher AQHI values. However, these high AQHI values are rare, usually only occurring during high smoke concentrations from forest fires. Similar results have been found in other communities in Canada.

18.6 AQHI Categories and Health Messaging

The relationship between the AQHI and its component pollutants is essentially linear for common ranges of these pollutants. Also, there is no health evidence that supports specific thresholds or step-changes for the AQHI as pollutant concentrations increase. However, stakeholder focus studies revealed that a key part of health messages would require separating AQHI values into separate health risk categories, each corresponding to a range of AQHI values. These categories were labelled *Low, Moderate, High* and *Very High* health risk. These categories and the corresponding health advice are described in Fig. 18.4.

A cornerstone in the development of the AQHI was the formulation of prescriptive health messages to communicate the risk posed by air quality and the specific actions which can be taken to reduce exposure and health effects. However, developing air quality messages that are both informative and focused towards fostering behavioral-change are complicated within the context of competing public health priorities (Henderson et al. 2004). An example is the recommendation for vulnerable people to stay indoors on days where the air quality is significantly degraded, while not discouraging the benefits of outdoor recreational activity. Therefore, an integrated program of mental models research and public opinion research was conducted to support the development of the health messages (Henderson et al. 2004)

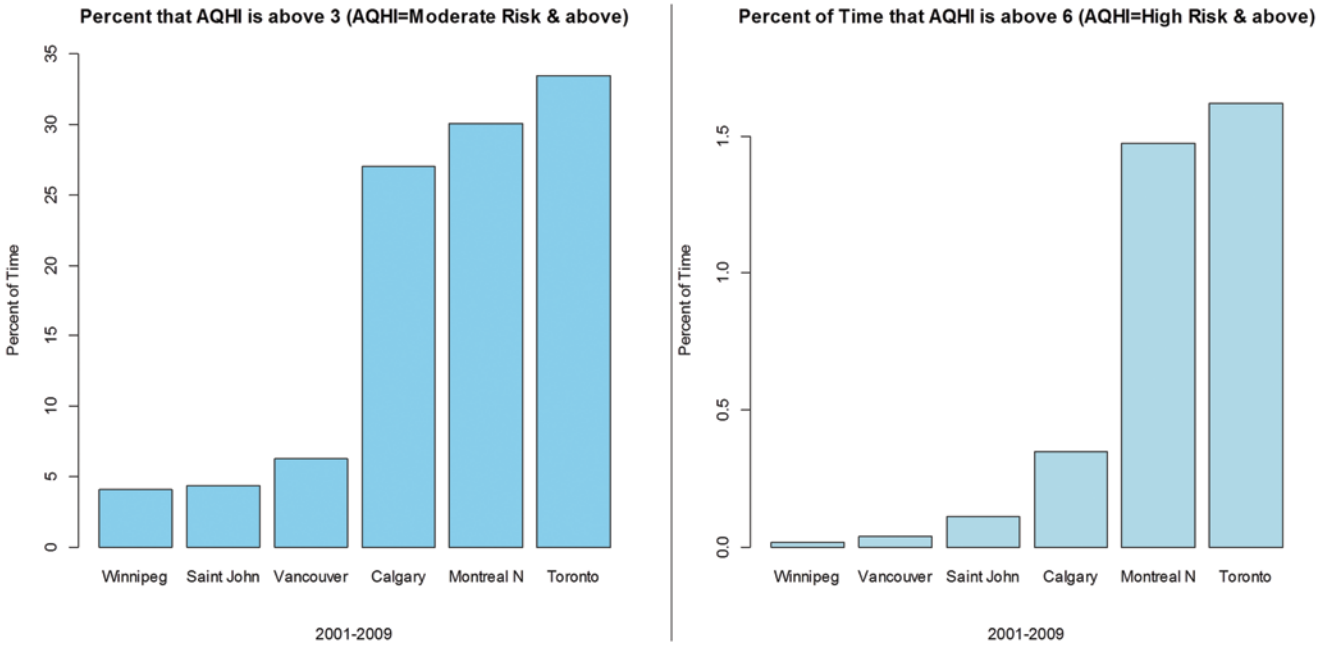
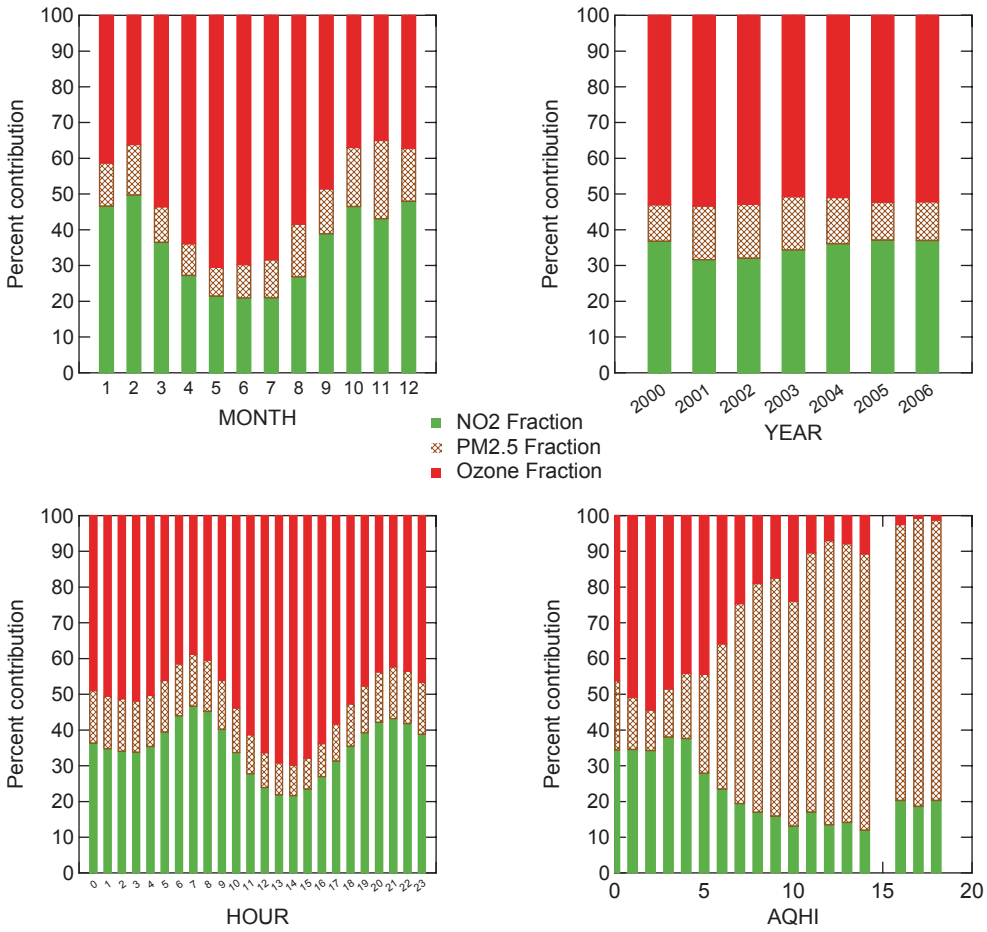


Fig. 18.2 The *left hand* graph shows the percent of time that the AQHI is in the Moderate (or above) Health Risk categories for six Canadian cities. The *right hand* graph shows the percent of time the AQHI is in High Health Risk or above category. These graphs indicate that Montreal and Toronto experience these elevated health risk categories much more frequently than Winnipeg, Vancouver, Saint John or Calgary

Fig. 18.3 The relative contribution of three pollutants, ozone, $PM_{2.5}$ and NO_2 to the AQHI value in Kelowna, BC. Starting with the graph in the *top left corner* and going clockwise, the graphs show the percent contribution of each pollutant by month, year, AQHI value and hour



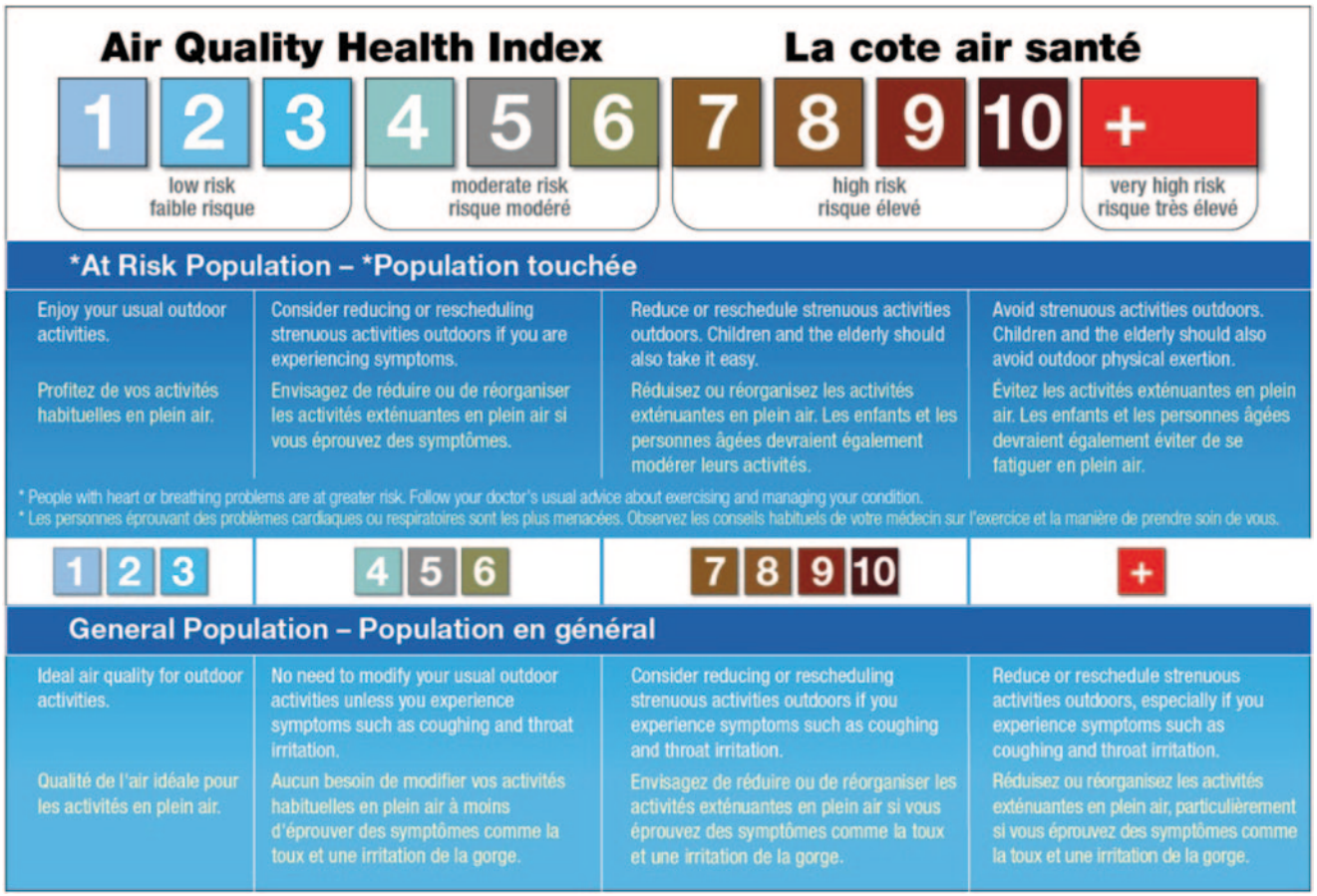


Fig. 18.4 The AQHI has four categories, corresponding to low, moderate, high and very high health risk. Specific health messaging is provided for the at-risk population and the general population. (Image courtesy of the Government of Canada)

Though all people have the potential to develop health symptoms as air quality deteriorates, health risk varies from person to person depending on their age, underlying health and sensitivity to air pollutants. The health advice provided by the AQHI system reflects this concept by providing health advice for the "at-risk" population that is more restrictive and cautious than for the general population. The "at-risk" population is defined as individuals with existing respiratory or cardiovascular conditions, young children, the elderly and those active outdoors.

Figure 18.4 associates the four AQHI categories with their corresponding AQHI values and health messages. For example, the health advice for an AQHI in the "moderate health risk" category for the "at-risk" population is:

Consider reducing or rescheduling strenuous activities outdoors if you are experiencing symptoms. People with heart or breathing problems are at greater risk. Follow your doctor's usual advice about exercising and managing your condition.

For the general population, the message is less restrictive:

- No need to modify your usual outdoor activities unless you experience symptoms such as coughing and throat irritation.

Figure 18.5 provides an example of the Environment Canada website display of the AQHI that provides the current and predicted AQHI values and categories, along with the specific health messages.

Individuals are also encouraged to "self-calibrate" by associating any pulmonary or cardiac symptoms to a specific AQHI value when air quality deteriorates. The theory behind this approach is that individuals can then take action in the future to reduce their exposure to air pollution when these AQHI values are either occurring or predicted. Anecdotal evidence suggests that self-calibration may offer a degree of protection, though the approach has yet to be tested rigorously.

Lacking from most discussions on air quality is what medical interventions can be offered for individuals who are at-risk for developing negative consequences from degraded air quality. Current health messaging is based on best available knowledge and expert opinion. Further exploration of the impacts of health messaging, and the acceptance by individuals to adopt recommended practices is required. For example:

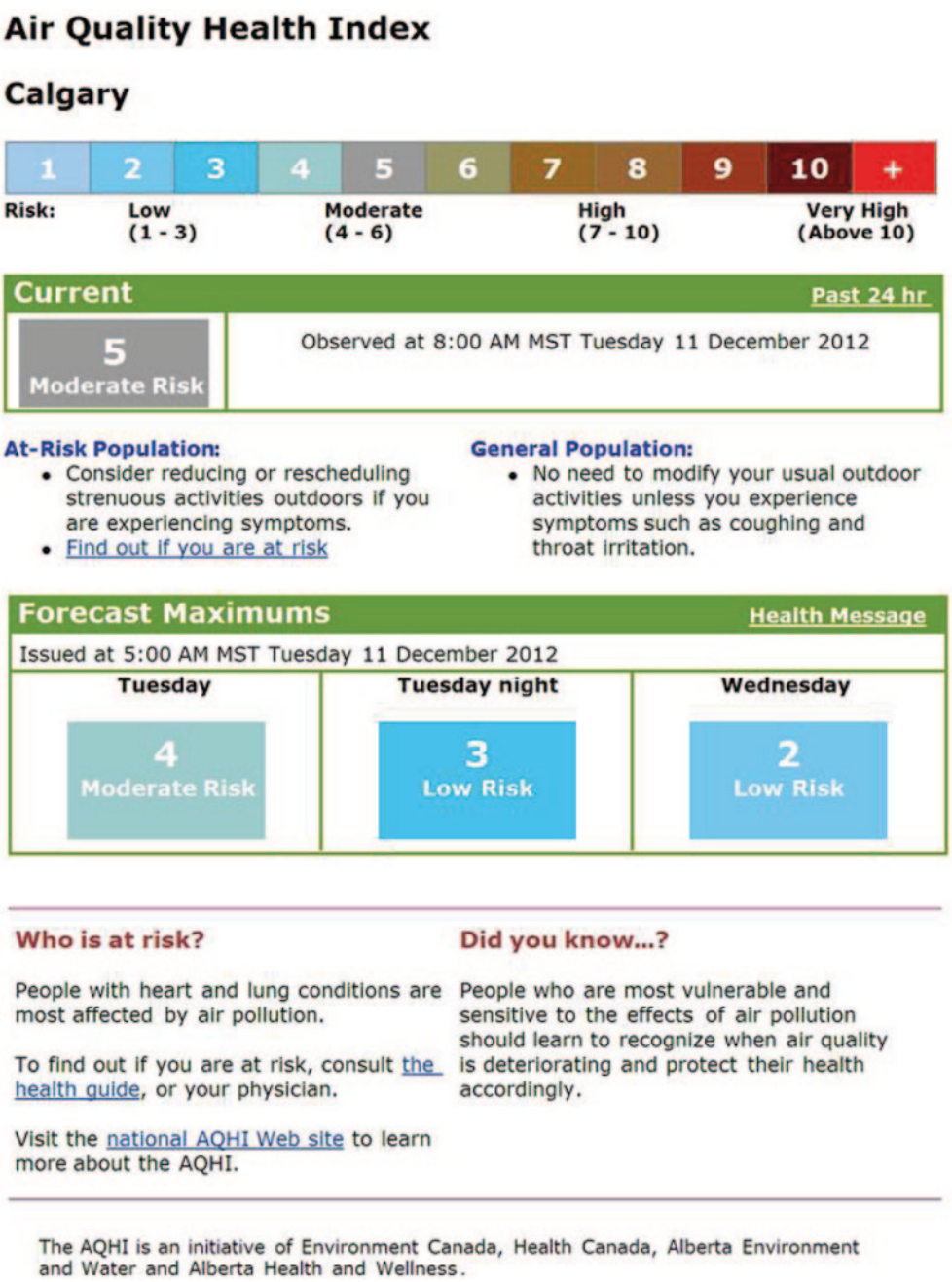


Fig. 18.5 This example of the Air Quality Health Index for Calgary on Environment Canada's website shows the current and predicted AQHI values as well as health advice. Clicking on the "forecast maximum" values displays the appropriate health message for that AQHI value

- What changes are required in personal asthma or COPD plans such as modification of medications or oxygen flow rates?
- Are there particular cardioprotective measures to be instituted in poorer air quality environments and days?
- Will some individuals have better health if relocated to different communities?

The usability of the AQHI will be improved as researchers, patients, and interested persons begin to explore how to employ the AQHI to both reduce negative health impacts and contribute to health improvement (Hasselback and Taylor 2009).

It is important to emphasize that the AQHI is not intended to address the health impact on individuals of long term (multi-year or multi-decadal) exposure to air pollutants. The AQHI was designed as a tool that can be used by the public to reduce their *short term* exposure to air pollution and plan, on a daily basis, to modify their behaviour and reduce their personal health risk. The AQHI therefore responds to the acute, or short-term, changing levels of risk associated with air pollution.

18.7 Communicating the AQHI and Health Messages

Environment Canada now broadcasts the hourly AQHI value for 74 communities across Canada through its website on a real-time basis. The air pollutant data needed for the calculation are provided in real time by provincial and territorial air quality agencies[1]. Environment Canada also routinely predicts the AQHI over the next 24–36 h for each community. More information on forecasting the AQHI can be found in Chap. 6 in this book. This information, the associated AQHI health risk category and the appropriate health messaging (Fig. 18.4) is communicated to the public through websites and other media. Several other Canadian jurisdictions also provide AQHI information in real-time through the internet.

18.7.1 Adaptation of the AQHI and Messaging for Specific Circumstances

The basic AQHI formula is the same for all communities in Canada. However, Environment Canada has agreed to accommodate some jurisdictions during extreme pollution events when there are conflicts between the AQHI and other measures of air quality. For example, in Alberta, additional pollutants are also considered when reporting the AQHI. These pollutants include sulphur dioxide, hydrogen sulfide, total reduced sulphur and carbon monoxide. Hourly concentrations of these pollutants are compared to Alberta Ambient Air Quality Objectives and on the rare occasion that objectives are exceeded, the AQHI value is increased to reflect a higher health risk. This modification of the index allows the AQHI to respond quickly to single-pollutant events on an hourly basis.

Special community-based messaging for odour or visibility is also a feature of the AQHI in Alberta, since the public identifies these factors with degraded air quality. This special messaging is provided when pollutant concentrations reach specific thresholds for odour and visibility in communities, for example during smog conditions, wildfire smoke episodes or as a result of nearby industrial activity. Despite this visibility or odour—related messaging, the AQHI values may not indicate that the air quality is significantly degraded

A parallel AQHI formula that replaces $PM_{2.5}$ with PM_{10} (particulate matter less than 10 microns in diameter) is used on rare occasions in some communities, particularly in British Columbia, when high dust levels are causing or expected to cause elevated PM_{10} concentrations.

[1] Canada is comprised of ten provinces (British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Québec, New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland and Labrador) and three territories (Yukon, Northwest Territories, and Nunavut).

In Quebec, there are several differences in the way the AQHI is communicated to the public compared to other provinces and territories.

18.7.2 La cote air santé au Québec (English translation follows)

Depuis décembre 2008, le Québec étudie, par le biais d'un projet pilote, la possibilité de mettre en place la Cote air santé (CAS) de manière permanente sur son territoire. Trois localités urbaines ont été sélectionnées soit Québec, Gatineau-Ottawa et l'Île de Montréal.

Les aspects distinctifs du projet pilote québécois de la CAS Le projet pilote québécois de la CAS se distingue du programme national, principalement dans son aspect communicationnel. Le premier aspect distinctif du projet pilote est de cibler spécifiquement les personnes vulnérables aux effets à court terme de la pollution atmosphérique (personnes souffrant de problèmes respiratoires et cardiovasculaires) parce qu'elles sont plus susceptibles de ressentir les effets d'une élévation ponctuelle des concentrations ambiantes de pollution atmosphérique. Le second aspect distinctif est de communiquer aux personnes vulnérables *le bon message, par le bon moyen et au bon moment*. Afin de répondre à ces orientations distinctives, différentes adaptations ont été apportées à la CAS nationale afin de l'appliquer au Québec:

- un seuil d'alerte a été défini afin de communiquer les recommandations de santé aux personnes vulnérables *seulement* lorsque la CAS atteint ce seuil;
- les recommandations de santé de la CAS ont été révisées afin qu'elles soient mieux adaptées à la situation des personnes vulnérables;
- des mécanismes spécifiques de diffusion, notamment un service automatisé d'alertes téléphoniques, ont été développés afin de diffuser efficacement et au moment opportun les recommandations de santé aux personnes vulnérables;
- une stratégie de promotion de la CAS ciblant spécifiquement les personnes vulnérables a été mise sur pied.

Seuil d'alerte En l'absence de seuil, le risque à la santé et les recommandations associées sont communiqués continuellement, risquant ainsi de compromettre, avec le temps, l'intérêt des personnes vulnérables pour le message. C'est pour cette raison qu'un seuil d'alerte a été fixé dans le cadre du projet pilote pour une valeur de CAS supérieure ou égale à 6. De cette façon, les personnes vulnérables sont avisées de l'élévation du niveau de risque pour la santé seulement lorsque la CAS atteint ce seuil.

Recommandations de santé Les recommandations de santé du programme national ont été adaptées afin qu'elles soient claires sur les comportements préventifs à adopter et reflètent davantage l'expérience personnelle des personnes vulnérables. De surcroit, la variation des recommandations de santé selon le niveau de risque a été revue afin qu'elles suggèrent une modification de comportements seulement lorsque la valeur de la CAS atteint le seuil d'alerte (CAS$\geq$6). Enfin, les catégories de risque présentes sous l'échelle ont été supprimées et remplacées par une flèche afin de mieux illustrer que le risque pour la santé associé à la pollution atmosphérique est sans seuil.

Mécanismes de diffusion Les valeurs de la CAS sont diffusées au Québec par le biais de trois services:

- un site Internet dédié présentant la CAS (www.coteairsante.qc.ca), les populations vulnérables et les effets de la pollution atmosphérique sur la santé. Les niveaux observés actuels et prévus, l'évolution des niveaux atteints durant 48 dernières heures ainsi que les recommandations en matière de santé peuvent être consultés pour les 3 régions du projet pilote. De plus, le site propose gratuitement un service d'abonnement et de désabonnement aux alertes;
- une ligne téléphonique sans frais (1 866 688-3810) permettant à l'usager de s'informer de la valeur CAS actuelle, des recommandations santé et de s'abonner au service d'alertes téléphoniques;
- un service automatisé d'alertes par téléphone, message texte ou courriel permettant à l'abonné de recevoir des avis lorsque la CAS atteint le seuil d'alerte.

Promotion de la CAS et sensibilisation Les activités de communication visaient principalement la population vulnérable à la qualité de l'air, cible principale du projet pilote québécois. La stratégie adoptée consistait à relayer l'information grâce aux professionnels de la santé et certaines associations pertinentes. L'objectif de la promotion était de faire connaître la CAS aux personnes vulnérables, de les sensibiliser aux enjeux associés à la qualité de l'air et de susciter leur adhésion aux services de la CAS (service gratuit d'alertes téléphoniques, ligne téléphonique sans frais et site Internet). Les moyens de communication élaborés consistaient en un dépliant d'information et un aimant promotionnel. Ces outils ainsi que les moyens de communication mis en ligne (hyperliens, bandeaux) sur les sites Internet des associations partenaires pointaient systématiquement vers les trois services.

La CAS et les autres outils d'information liés à la qualité de l'air Il existe, au Québec, d'autres outils d'information liés à la qualité de l'air soit l'Indice de qualité de l'air (IQA) et le programme Info-Smog. L'IQA qualifie la qualité de l'air de bonne, acceptable ou mauvaise en fonction de la concentration de certains polluants. Pour sa part, le programme Info-smog fourni une prévision et des alertes en lien avec les épisodes de smog. Ces indices sont fondés sur le dépassement de normes et de critères ce qui les différencie de la CAS qui se base sur les risques à la santé engendrés par une combinaison de polluants.

Dans certaines conditions, lorsque la concentration de polluants, en particulier les $PM_{2,5}$, dépasse le critère utilisé par l'IQA, le seuil d'alerte de la CAS peut ne pas être atteint. Il en découle une contradiction entre les messages véhiculés par ces différents indices. Afin de remédier à cette situation, un système de bannière a été mis en place sur le site Internet de la CAS. Lorsque la qualité de l'air est jugée mauvaise selon l'IQA et que la CAS est inférieure à 6, une bannière informant de la mauvaise qualité de l'air et des recommandations de santé inhérentes est affichée. Si la bannière est affichée durant plus de trois heures consécutives, le service d'alertes envoie des alertes aux abonnés avec un message santé différencié de ceux reliés à la CAS.

Avenir de la CAS au Québec En mars 2012, les autorités de santé publique impliquées dans le projet se sont prononcées en faveur de la poursuite du projet pilote au Québec jusqu'en mars 2015 à condition de conserver l'IQA, le programme Info-Smog et de réviser l'importance des $PM_{2,5}$ dans la formulation de la CAS. Le projet se décline en trois étapes. La première consiste en l'ajout de stations de mesure dans la région de Québec et de Gatineau. Sous réserve d'approbation des différents partenaires et de la disponibilité des budgets requis, l'étape suivante verra le développement de la CAS dans les couronnes nord et sud de Montréal. Finalement, et sous les mêmes conditions, le service pourrait être étendu à 3 autres régions urbaines soit celles de Saguenay, Sherbrooke et Trois-Rivières. À la fin du projet pilote, les autorités ministérielles se verront proposer une recommandation favorable ou non à l'adoption définitive de la CAS au Québec.

The Air Quality Health Index in Québec In December 2008, Québec initiated a pilot project to assess the possibility of implementing the Air Quality Health Index (AQHI) throughout the province. Three urban centres were selected for this pilot: Québec City, Gatineau-Ottawa, and the Island of Montréal.

Distinctive aspects of the Québec AQHI pilot project The Québec AQHI pilot project differs from the national AQHI program, primarily in its approach to communication. Firstly, it specifically targets those who are vulnerable to the short-term effects of air pollution (people suffering from respiratory and cardiovascular problems) since they are more likely to suffer the effects of elevated concentrations of ambient air pollution. Secondly, it communicates to vulnerable people *the right message, in the right manner, and at the right time.* In order to

meet these guidelines, the following adjustments have been made to the national AQHI program in Québec:

- An alert threshold has been defined to communicate health advice to vulnerable people only when the AQHI reaches this specific threshold;
- The AQHI health advice has been revised so that it is better tailored to vulnerable persons;
- Specific mechanisms of communication, most notably automated phone alerts, effectively disseminate health advice to vulnerable people in a timely fashion;
- A strategy to promote the AQHI by specifically targeting vulnerable people.

Alert Threshold In the absence of a defined AQHI threshold, the health risk and the associated health advice messages are communicated continuously to the public. This may cause vulnerable people to ignore this repetitive information because of so-called "message fatigue". This is the reason that an AQHI value greater than or equal to 6 has been established as a warning threshold. In this way, vulnerable persons are advised of the elevated level of health risk only when the AQHI reaches this threshold.

Health Advice The health advice provided by the national AQHI program has been modified to be clearer with respect to protective behaviours that users should adopt, and also to more accurately reflect the personal experience of those vulnerable to air pollution. In addition, the advice related to the level of health risk has been revised such that a change in behaviour is recommended only when the value of the AQHI reaches the alert threshold (AQHI greater than 5). Finally, the various risk categories presented immediately below the standard AQHI scale on the website have been replaced by a single, continuous arrow (extending from low to high AQHI values) to better demonstrate that the health risks associated with air pollution are not related to any specific AQHI threshold.

Dissemination mechanisms AQHI values are disseminated in Québec through three services:

- A website (http://www.coteairsante.qc.ca/default.aspx?lang=en) dedicated to the presentation of the AQHI. This describes those who are vulnerable to air pollution and summarizes the effects of air pollution on health. It also provides the current and forecasted AQHI values, the hourly values over the last 48 hours, as well as health advice for the three pilot project areas. In addition, the site offers a free subscription service for AQHI alerts.
- A toll-free line (1 866 688-3810). This provides the current AQHI observation and related health advice, and the opportunity to subscribe to the telephone alert service;
- An automated system of alerts by phone, text message, and e-mail. These permit subscribers to receive notifications when the AQHI reaches the prescribed alert threshold.

AQHI Promotion and Awareness Communication activities are primarily intended for those vulnerable to air pollution, the main target of the pilot project in Québec. The strategy is to relay information through health professionals and certain relevant associations. The objective of the promotion program is to inform vulnerable people about the AQHI, raise awareness of the issues associated with air quality, and encourage the use of the AQHI services (free alerts by phone, a toll- free phone line, and website). Communication materials consist of an information brochure and a promotional magnet. These tools, as well as those developed for the online environment (hyperlinks and banners on the websites of partner organizations) consistently point to these services.

AQHI and Other Information Tools Relating to Air Quality There are, in Québec, other information tools related to air quality. These are the Air Quality Index (AQI) and the Info-Smog program. The AQI describes the air quality as *good, fair,* or *poor* depending on the concentrations of certain pollutants. The Info-Smog program provides forecasts and alerts related to smog episodes. These indices are structured around the exceedance of standards or select criteria defined for single pollutants. This differentiates them from the AQHI which is based on the health risks caused by a combination of pollutants.

Under certain conditions, when the concentration of pollutants, in particular $PM_{2.5}$, exceeds the criterion used by the AQI, the AQHI may not exceed the defined threshold value for alerts. This leads to a disagreement between the messages conveyed by the AQHI and the AQI. To remedy this, a banner is used on the AQHI web site. If the air quality is judged to be degraded according to the AQI, but the AQHI remains below 6, a banner is posted informing the public of degraded air quality and provides appropriate health advice. If the banner is displayed for more than three consecutive hours, the alert service is activated to provide subscribers with a special health message, which differs from the AQHI health message.

The Future of the AQHI in Québec Following a decision made in March 2012, local public health authorities involved in the AQHI project supported the continuation of the AQHI pilot project in Québec until March 2015, provided that that the AQI and the Info-Smog program remain and that a review is undertaken of the importance of $PM_{2.5}$ in the AQHI formula. Expansion of this project has been divided into three stages. The first is the addition of monitoring stations in Québec City and Gatineau. Subject to the approval of the various partners and the availability of required budgets, the next step will be the implementation of the AQHI

in the suburbs to the north and south of Montréal. Finally, and under the same conditions, the service could be extended to three additional urban areas: Saguenay, Sherbrooke, and Trois-Rivières. At the end of the pilot project, the Québec government will make a recommendation for or against the final adoption of the AQHI in Québec.

18.7.3 AQHI Applicability in Large and Small Communities

To establish robust epidemiological links between air pollution and mortality data, health studies need to rely on information from hundreds of thousands of individuals, typically in *large urban areas*, since only about 0.1 to 1% of mortality is attributable to air pollution (British Columbia Provincial Health Officer 2004). We can therefore have the greatest confidence that the AQHI accurately reflects health risk in similar urban settings where the mix of air pollution is largely derived from local vehicle emissions together with regional "smog". In rural settings or small communities where sources are much different, the AQHI may predict health risks less accurately. Note that this difficulty pertains to any measure that links air quality and health, including provincial or federal air quality objectives and trigger levels for air quality advisories, not just the AQHI.

Similarly, both the AQHI as well as air quality objectives and standards may confer different levels of protection where air pollution sources and mixtures are different. For example, 25 μ/m^3 of $PM_{2.5}$ may differ in toxicity depending on whether it is derived from wildfire smoke, extremely fine crustal material, or urban smog.

18.8 Promoting the AQHI

Promotion of the AQHI to the public continues to be an essential component of the AQHI program (Fig. 18.4). A communication initiative was developed using a pan-Canadian process that engaged hundreds of stakeholders that included the public, private and non-profit/voluntary sector. This process was a partnership between Environment Canada, Health Canada and key municipal and provincial colleagues that assessed a wide range of views on how the AQHI information should be displayed, accessed and used. Issues resolved in this process included defining the objectives of the AQHI, identifying the audience for the index, assessing different audience needs and testing AQHI communication materials and approaches.

Health Canada and Environment Canada have supported a number of projects across Canada to raise awareness of the AQHI. One of these was in Toronto where a significant effort was made to promote the use of the AQHI (Fig. 18.5). Another was in British Columbia where an extensive, multi-year campaign was implemented to promote the recognition and use of the AQHI throughout the province, particularly with a focus on the "at risk" population and, during the summer of 2010, the health risks associated with wildfire smoke in the interior of the province. More information on communication and promoting the AQHI is included in Chap. 19 on communicating air quality information in this book (Fig. 18.6).

Since changing weather in a community is an important reason for hourly and daily changes to air quality and the AQHI, Environment Canada has incorporated the observed hourly AQHI values for each community into its website http://weather.gc.ca/. It also provides the 24–36 h AQHI forecast with the related health messaging on this site. A number of municipal, provincial and private websites also provide AQHI and other air quality information, including the following:

- Alberta: http://environment.alberta.ca/0977.html.
- British Columbia: http://www.bcairquality.ca/readings/index.html
- Manitoba: http://www.gov.mb.ca/conservation/pollution-prevention/airquality/aq-health/
- New Brunswick: http://www.gnb.ca/0053/public_health/air-e.asp
- Newfoundland and Labrador: http://www.env.gov.nl.ca/env/env_protection/science/aqhi.html
- Nova Scotia: http://www.gov.ns.ca/nse/aqhi/
- Prince Edward Island: http://www.gov.pe.ca/health/index.php3?number=1021134&lang=E
- Québec: http://www.coteairsante.qc.ca/Default.aspx?lang=en
- Toronto: http://www.toronto.ca/health/airquality/aqhi/faq.htm
- Weather Network: http://www.theweathernetwork.com/airquality/cancitiesaq_en/

18.9 The AQHI in the Future

Several areas of research are planned for the AQHI. Health-focussed research areas include self calibration of the index, exercise and exposure to air pollutants, applicability of the index to sensitive populations, and communication of the health risk. Other areas include the applicability of the AQHI to rural populations, indoor air quality vs. the outdoor AQHI, scientific formulation of the AQHI and the application of the index internationally (Health Canada 2011).

More methods will be developed to lower health risk. For example, a promising tool is being designed to give advice to asthmatics by integrating the AQHI into their asthma action plans. This system uses a combination of an electronic asthma action plan with the current and predicted AQHI to provide health advice to patients. This advice is based on clinical data on symptoms and other indicators that patients

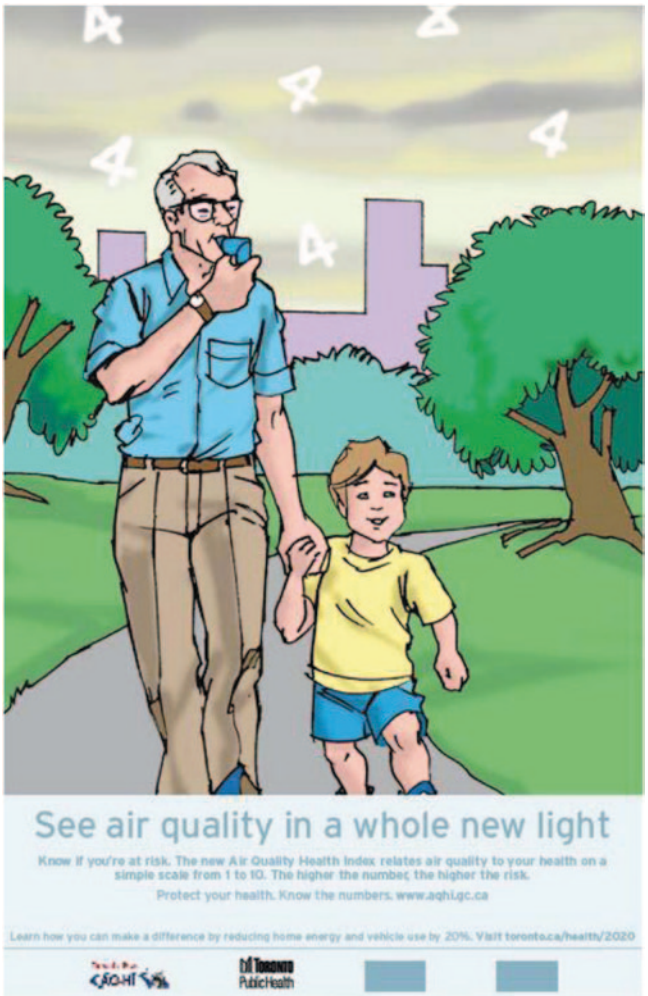


Fig. 18.6 A poster promoting the relation between the AQHI and health risk. (Image courtesy Toronto Public Health)

routinely send to a server. The communication is based on a web-based smart phone application (Licskai et al. 2012).

18.10 Conclusion

The Air Quality Health Index promises to be a practical tool to provide Canadians with local air quality information on an hourly and daily basis that can be used to protect their health from the negative impacts of air pollution. It can also be used as a measure to compare the short term health risk due to air pollution in different communities, with some caveats.

The good news is that air quality tends to be improving through the collective efforts of public education, monitoring and enforcement, better engineering, and mitigation of known polluting sources. Air quality can be measured through existing air quality monitoring systems and can be synthesized into a simple communication tool in the AQHI. This Index can reach the majority of the Canadian population, although many communities still lack the monitoring systems required to generate the AQHI. Further experience with the AQHI will help to identify better how to intervene with individuals and populations to act to reduce our risk from poorer air quality (Hasselback and Taylor 2009).

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